4.1.5.2 Impacts to Cultural Resources from Construction, Operation and Monitoring, and Closure

Impacts to archaeological and historic sites could occur during the initial construction phase and the operation and monitoring phase, when ground-disturbing activities would take place. Indirect impacts to archaeological and historic sites could occur during all phases of the Proposed Action.

Archaeological and Historic Resources

Potential impacts to *National Register*-eligible cultural resources from surface facility construction could occur in areas where ground-disturbing activities would take place. Repository development would disturb a maximum of about 4.5 square kilometers (1,100 acres) of previously undisturbed land at the site.

Archaeological investigations conducted in the immediate vicinity of the proposed surface facilities in support of previous and ongoing characterization studies and infrastructure construction have identified about 830 archaeological and historic sites. These investigations have identified resource localities and provided mitigative relief for resources potentially subject to direct impacts (DIRS 104997-CRWMS M&O 1999, Table 2). In addition, ground-disturbing activities associated with potential nearby project actions (for example, upgrades to utility and road rights-of-way, rail access facilities, excavated rock and other onsite storage areas) would occur in areas that had undergone field inventories and evaluations of cultural resources.

Several known archaeological sites in the vicinity of Midway Valley could be affected by ground-disturbing activities associated with the construction of the surface aging facility. An archaeological site occupies much of Midway Valley, including the general location of the proposed surface aging facility. This site was partially mitigated during site characterization activities in 1991 (DIRS 153162-Buck, Amick, and Hartwell 1994, all). In addition, intensive mitigation efforts were conducted at a nearby archaeological site in 1993, yielding nearly 25,000 artifacts (DIRS 153167-Buck et al. 1998, all). Other known archaeological sites occur in the vicinity of the possible location of the solar power generating facility. These sites have not been evaluated beyond field recording, some having been identified more than 20 years ago. One or more of these sites could be affected by construction at the primary location for the solar power generating facility, as well as such features as access roads and transmission cables.

Increases in both surface activities and numbers of workers at the repository site could increase the potential for indirect impacts at archaeological sites near repository surface facilities. Preliminary results from the monitoring of archaeological sites in the vicinity of Yucca Mountain activities since 1991 indicate that human activities and increased access could result in harmful effects, both intentional and inadvertent, to these fragile resources (DIRS 104997-CRWMS M&O 1999, Chapter 1). Indirect impacts are difficult to quantify and control, but they can include loss of surface artifacts due to illicit collection and inadvertent destruction (DIRS 104997-CRWMS M&O 1999, Chapter 1).

Even though there could be some indirect adverse impacts, the overall effect of the repository on the long-term preservation of the archaeological and historic sites in the analyzed land withdrawal area would be beneficial. Cultural resources in the area would be protected from most human intrusion.

Excavation activities at the repository site could unearth additional materials and features in areas that past archaeological surveys have examined only at the surface. Past surveys in the Yucca Mountain area indicated buried cultural materials at some sites with surface artifacts (DIRS 104997-CRWMS M&O 1999, Chapter 1). Thus, excavation activities could unearth previously undetected subsurface features or artifacts. If this happened, work would stop until a cultural resource specialist evaluated the importance of the discovery.

Native American Viewpoints

DOE would continue the existing Native American Interaction Program (see Chapter 3, Section 3.1.6.2) throughout the Proposed Action. This program promotes a government-to-government relationship with associated tribes and organizations. Continuation of this program during the Proposed Action would enhance the protection of archaeological sites and cultural items important to Native Americans.

The Native American view of resource management and preservation is holistic in its definition of "cultural resource," incorporating all elements of the natural and physical environment in an interrelated context. Moreover, this view includes little or no differentiation between types of impacts (direct versus indirect), but considers all impacts to be adverse and immune to mitigation. Section 4.1.13.4 contains an environmental justice discussion of a Native American viewpoint on the Proposed Action.

Previous studies (DIRS 103465-Stoffle et al. 1990, all; DIRS 102043-AIWS 1998, all) have delineated several Native American sites, areas, and resources in or immediately adjacent to the analyzed land withdrawal area. Construction activities for repository surface facilities would have no direct impacts on these locations. However, because of the general level of importance attributed to these places by Native Americans, and because they are parts of an equally important integrated cultural landscape, Native Americans consider the intrusive nature of the repository to be an adverse impact to all elements of the natural and physical environment (DIRS 102043-AIWS 1998, Chapter 2). In their view, the establishment of the protected area boundary and construction of the repository would continue to restrict the free access of Native American people to these areas. On the other hand, the Consolidated Group of Tribes and Organizations has recognized that past restrictions on public access due to site characterization have resulted in generally beneficial and protective effects for cultural resources, sacred sites, and potential traditional cultural properties (DIRS 102043-AIWS 1998, Chapter 2).

The potential for indirect impacts from construction activities and more workers in the area would increase, particularly to the physical evidence of past use of the cultural landscape (artifacts, cultural features, archaeological sites, etc.) important to Native American people. DOE would continue to provide training to workers to minimize the potential for indirect impacts.

Eventual closure of the repository would have the beneficial effect of returning much of the disturbed landscape to a natural setting. Some additional impacts could occur to resources or areas important to Native Americans if changes in land status or management that occurred after closure led to increased access by the public. The presence of a permanently entombed repository would represent an intrusion into what Native Americans consider an important cultural and spiritual place. Long-term monitoring features or activities would continue to affect these cultural viewpoints.

4.1.6 SOCIOECONOMIC IMPACTS

This section describes potential socioeconomic impacts from preconstruction testing and performance confirmation, construction, operation and monitoring, and closure activities. Evaluations of the socioeconomic environment in communities near the proposed repository site considered changes to employment, economic measures, population, housing, and some public services. The evaluation used the Regional Economic Models, Inc. (REMI) model to estimate baseline socioeconomic conditions and to estimate economic and population changes caused by the Proposed Action. The potential for changes in the socioeconomic environment would be greatest in the Yucca Mountain region of influence where most of the repository workers would live. As discussed in Chapter 3, Section 3.1.7, this region of influence consists of Clark, Lincoln, and Nye Counties in southern Nevada.

DOE examined the maximum potential employment levels that would be required to implement the range of operating modes. The analysis did not project baseline population or employment in the region of influence beyond 2035 because of the speculative nature of such a forecast.

The discussion in this section of changes to population, employment, Gross Regional Product, real disposable income, and expenditures by the State of Nevada and local governments resulting from the Proposed Action are the deviations from a projected baseline for each parameter. This baseline utilizes data DOE received from the State and local governments. Chapter 3, Section 3.1.7 discusses this baseline.

DOE has considered suggestions made in public comments that the EIS include analysis of possible impacts of perceptions associated with the proposed repository. DOE has determined that it could not quantify any potential impacts resulting from such perceptions and that further research would be unlikely to make quantification possible. From a qualitative standpoint, adverse impacts from perceptions of the repository would be unlikely, absent a large accident or a continuing series of smaller accidents. Section 2.5.4 discusses the reasons for DOE's determination.

4.1.6.1 Socioeconomic Impacts from Preconstruction Testing and Performance Confirmation

The level of employment for preconstruction testing and performance confirmation activities would be similar to or less than the current level of employment for site characterization, as described in Chapter 3, Section 3.1.7. Because population and employment changes between ongoing site characterization activities and future performance confirmation activities would be minimal, there would be no meaningful impacts to housing or public services, including impacts to schools.

4.1.6.2 Socioeconomic Impacts from Construction, Operation and Monitoring, and Closure

4.1.6.2.1 *Impacts to Employment*

TERMS RELATED TO EMPLOYMENT

Direct Employment: Jobs expressly associated with project activity.

Indirect Employment: Jobs created as a result of expenditures by directly employed project workers (for example, restaurant workers or child care providers) or jobs created by the project-related purchase of goods and services (for example, sales manager of a concrete supply store).

Composite Employment: Sum of direct and indirect jobs.

In 2006, the peak year of employment during the initial construction phase, about 1,900 additional workers would also be employed on the Yucca Mountain Repository Project. Figure 4-2 shows composite (direct and indirect) employment changes caused by construction activities, by place of residence during this phase. Incremental employment increases during the construction phase attributable to the repository would peak in 2006 with the addition of about 3,400 workers to the region of influence. This would increase overall employment in the region of influence from the projected baseline (employment without the repository project) of approximately 942,000 jobs to slightly less than 945,000 positions, a change of approximately 0.36 percent. Table 4-14 summarizes repository peak year employment during the initial construction period by place of residence in selected communities. Table 4-15 lists the expected residential distribution of directly employed construction workers over the primary construction phase. These tables do not list Lincoln County because, historically, very few Yucca Mountain Project workers have resided in the County. DOE expects that few, if any, repository employees would live in Lincoln County given the long commute.

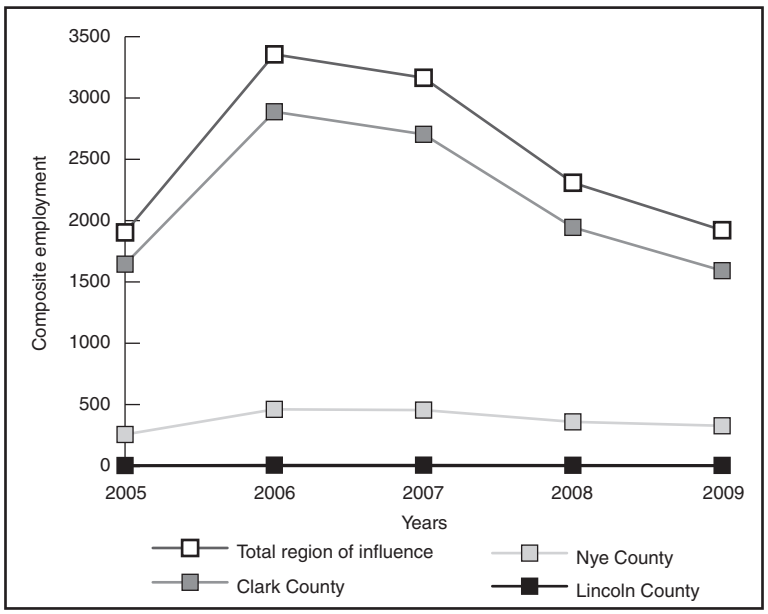

Figure 4-2. Increases in regional composite employment by place of residence during construction phase.

Table 4-14. Expected peak year (2006) increase in construction employment by place of residence in selected communities in Nye and Clark Counties.[a,b,c]

Location	Direct jobs[d]	Indirect jobs[d]	Total jobs[d]
Clark County			
Indian Springs	60	40	100
Rest of Clark County	1,440	1,360	2,800
Clark subtotals	*1,500*	*1,400*	*2,900*
Nye County			
Amargosa Valley	20	10	30
Beatty	3	2	5
Pahrump area	340	90	430
Nye subtotals	*360*	*100*	*460*
Totals[e]	***1,860***	***1,500***	***3,360***

a. Employment and population impacts distributed using residential patterns of Nevada Test Site and Yucca Mountain employees from DOE (DIRS 155987-DOE 2001, all).
b. DOE anticipates approximately 80 percent of repository workers would live in Clark County and approximately 20 percent in Nye County; includes approximately 5 indirect jobs in Lincoln County.
c. Employment in 2006 does not include approximately 220 current workers.
d. Numbers have been rounded to the nearest 10.
e. Totals might not equal sums of values due to rounding.

Table 4-15. Repository direct employment during construction phase by expected county of residence: 2005 to 2009.[a,b,c,d]

County	2005	2006	2007	2008	2009
Clark	1,000	1,660	1,660	1,360	1,300
Nye	240	410	400	330	320
Totals[e]	**1,240**	**2,070**	**2,060**	**1,700**	**1,610**

a. Sources: DIRS 104508-CRWMS M&O (1999, Section 6); DIRS 104523-CRWMS M&O (1999, Section 6).
b. DOE anticipates approximately 80 percent of repository workers would live in Clark County and approximately 20 percent in Nye County.
c. Includes approximately 220 current workers.
d. Numbers are rounded to the nearest 10.
e. Totals might not equal sums of values due to rounding.

Training of operational personnel would begin in 2009. In 2010, direct operational employment would start to increase. Direct operational peak employment would occur in 2012 (with about 2,150 workers). Employment after 2012 would be essentially stable with an average annual workforce of about 1,900 through the year 2033 when operations would be completed.

At the start of the monitoring period, a workforce of up to 1,160 workers would be involved in decontamination of surface facilities for a period of approximately 3 years. The impact to employment from the decontamination activities would be less than 1 percent of the estimated baseline. Figure 4-3 reflects this short-term increase. After decontamination was completed, direct employment would decrease substantially for the remainder of the monitoring period.

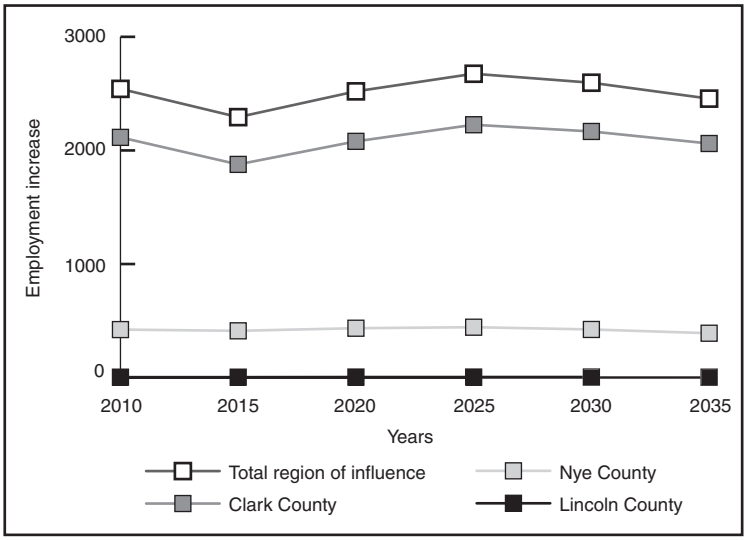

Figure 4-3. Changes in regional employment from operations period and decontamination activities.

Table 4-16 lists the expected residential distribution of repository workers in the peak year of employment (2012) during the operations period. The table also lists the estimated number of indirect jobs created in these communities during 2012. The direct and indirect employment in the region of influence would peak with the addition of approximately 2,700 workers. This would result in an incremental increase of employment from the estimated baseline of about 1,029,000 jobs to about 1,031,000 jobs, a change of less than 0.26 percent from the estimated employment baseline.

Table 4-17 summarizes direct repository employment through the first 24 years of the operation and monitoring phase by county of residence. This table does not list Lincoln County because, historically, so few workers have resided in the County. Figure 4-3 shows the direct and indirect regional employment differences between the bounding employment case for the lower-temperature operating mode with aging and the estimated baseline.

Monitoring and maintenance activities would start with the first emplacement of waste package and would continue through repository closure. DOE estimates that a workforce of approximately 120 workers would be needed to monitor and maintain the repository. Given the expected economic growth in the region of influence, the region could readily absorb declines in repository employment.

To bound this study, the socioeconomic analysis assumes that closure would begin 100 years after the start (and 76 years after the completion) of emplacement activities. The lower-temperature operating mode would require a longer monitoring period, ranging from 125 to 300 years. Therefore, this analysis evaluated potential impacts of a closure of the repository in the lower-temperature mode after as many as

Table 4-16. Expected peak year (2012) increases in operations period employment in selected communities in Clark and Nye Counties.[a]

Location	Direct jobs[b]	Indirect jobs	Total jobs
Clark County			
Indian Springs	70	20	90
Rest of Clark County	1,490	620	2,110
Clark subtotals	*1,560*	*640*	*2,200*
Nye County			
Amargosa Valley	20	10	30
Beatty	3	0	3
Pahrump area	350	70	420
Nye subtotals	*380*	*80*	*460*
Totals[c]	***1,940***	***720***[d]	***2,660***

a. Numbers have been rounded to the nearest 10.
b. Employment in 2012 does not include approximately 220 current workers.
c. Totals might not equal sums of values due to rounding.
d. Includes 4 indirect workers in Lincoln County.

Table 4-17. Repository direct employment during operations period and decontamination activities by county of residence: 2010 to 2035.[a,b,c]

County	2010	2015	2020	2025	2030	2035[d]
Clark total	1,630	1,600	1,650	1,640	1,560	1,420
Nye total	400	390	400	400	380	350
Totals[c]	***2,030***	***1,990***	***2,050***	***2,040***	***1,940***	***1,770***

a. Includes approximately 220 current workers.
b. Numbers have been rounded to the nearest 10.
c. Totals might not equal sums of values due to rounding.
d. Year 2035 shows the short-term (3-year) impact of decontamination activities.

324 years of operation and monitoring. Employment would be far less than the peak during the operation and monitoring phase and, therefore, would be unlikely to generate employment changes and economic measures of more than one-half of 1 percent. There probably would be no perceptible repository-induced changes to baseline employment in the region of influence. Regional impacts to socioeconomic parameters during the closure phase would be small.

4.1.6.2.2 *Impacts to Population*

From 2010 through 2035 the projected regional population will grow from about 1.9 million residents to approximately 2.8 million. The peak year population contribution attributable to the repository would be approximately 6,200 people, or approximately 0.24 percent of the region of influence's estimated population baseline of 2.6 million people in 2030. As a result, the Yucca Mountain Repository Project would have only small effects on the population growth in the region of influence. Figure 4-4 shows the projected population increase resulting from the repository project.

Table 4-18 lists estimated incremental population increases that would occur as a result of repository activities in Clark and Nye Counties based on historic Nevada Test Site residential distribution patterns. As mentioned above, repository workers would be unlikely to reside in Lincoln County. The incremental peak population increase in Clark County would be less than 0.21 percent.

Population growth associated with the repository would be more evident in Nye County. The County's population increase would be approximately 1.4 percent of the projected population of 77,000, for the County in 2030, the peak year for potential repository population impacts.

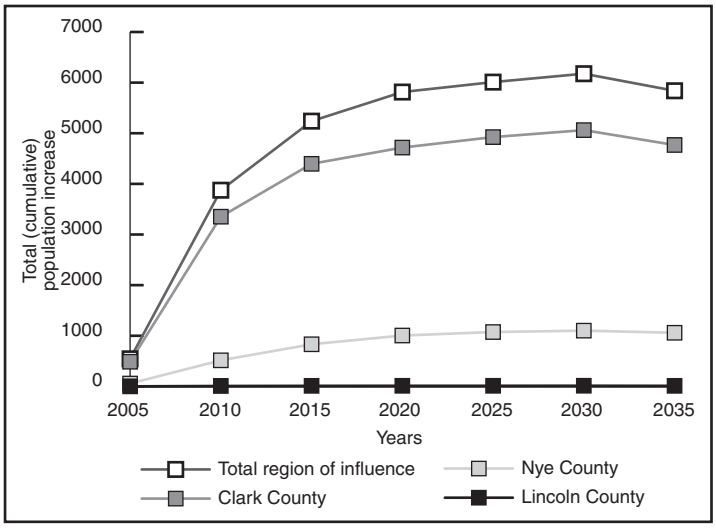

Figure 4-4. Regional population increases from construction and operations: 2005 to 2035.

Table 4-18. Maximum expected population increase from Proposed Action (2030).[a,b]

Location	Population increase
Clark County	
Indian Springs	180
Rest of Clark County	4,880
Clark total	***5,060***
Nye County	
Amargosa Valley	80
Beatty	10
Pahrump	1,000
Nye total	***1,100***

a. Numbers have been rounded to the nearest 10.
b. Totals might not equal sums of values due to rounding.

4.1.6.2.3 *Impacts to Economic Measures*

Table 4-19 lists estimated changes in economic measures that would result from repository activities during the construction phase (values are expressed in 2001 dollars). Increases in real disposable income within the region of influence would peak in 2007 with an increase of about $110 million, while increases in Gross Regional Product would peak in 2006 at about $160 million. Regional expenditures by State and local governments would peak at $11 million in 2009. Economic measures for the region of influence would increase by less than one-third of 1 percent over the projected baseline (estimated economic measures without the repository project).

Table 4-20 lists the changes in economic measures that would result from the repository project duringthe operations period. Increases in Gross Regional Product would peak in 2029 at about $125 million. Increases in real disposable income would peak in 2029 at $149 million. Increases in regional expenditures by State and local governments under the maximum employment case would peak in 2030 at about $22 million. Economic measures for the region of influence would increase by less than 0.5 percent over the projected baseline.

GROSS REGIONAL PRODUCT

The value of all final goods and services produced in the region of influence.

4.1.6.2.4 *Impacts to Housing*

Given the size of the regional employment, the number of workers in-migrating to work on the repository would be relatively small. Because the inmigration would be small, the increased demand for housing would also be small.

Table 4-19. Increases in economic measures within the region of influence from repository construction: 2005 to 2009 (millions of dollars).[a]

Jurisdiction	2005	2006	2007	2008	2009
Clark County					
Disposable income	54	100	103	85	77
Gross Regional Product	80	142	136	100	73
State and local government expenditures	1.5	4.8	7.6	9.1	9.9
Nye County					
Disposable income	3.7	6.7	6.8	5.7	5.9
Gross Regional Product	10	19	18	15	12
State and local government expenditures	0.2	0.5	0.9	1	1.3
Lincoln County					
Disposable income	0.1	0.3	0.3	0.2	0.2
Gross Regional Product	0.1	0.2	0.2	0.2	0.1
State and local government expenditures	0	0	0.1	0.1	0.1
Total region of influence[b]					
Disposable income	58	108	110	90	83
Gross Regional Product	90	160	155	115	85
State and local government expenditures	1.7	5.3	8.5	10	11

a. Numbers are expressed in 2001 dollars.
b. Totals might differ from sums of values due to rounding.

Table 4-20. Increases in economic measures within the region of influence from emplacement and development activities: 2010 to 2033 (millions of dollars).[a]

Jurisdiction	2010	2015	2020	2025	2030	2033
Clark County						
Disposable income	97	104	119	129	133	110
Gross Regional Product	90	82	96	106	105	69
State and local government expenditures	11	15	16.7	18	18	17
Nye County						
Disposable income	8.2	11	13	14	15	14
Gross Regional Product	15	15	16	17	17	12
State and local government expenditures	1.6	2.6	3.2	3.5	3.7	3.6
Lincoln County						
Disposable income	0.3	0.3	0.3	0.4	0.4	0.3
Gross Regional Product	0.2	0.2	0.2	0.2	0.2	0.2
State and local government expenditures	0.1	0.1	0.1	0.1	0.1	0.1
Total region of influence[b]						
Disposable income	106	115	132	144	149	124
Gross Regional Product	104	97	113	123	122	81
State and local government expenditures	12	18	20	21	22	21

a. Numbers are expressed in 2001 dollars.
b. Totals might differ from sums of values due to rounding.

The impact to housing would be minimal because (a) the expected increase in population is so small, (b) the demand is expected to be concentrated in a metropolitan area (Clark County), (c) there are no municipal or state growth control measures that limit housing development, and (d) the region of influence has an adequate supply of undeveloped land to meet expected future demands. Southern Nye County, particularly Pahrump, would experience some demand for housing. In Lincoln County, little or no demand for housing resulting from repository activities would be likely, so housing availability would not be an issue.

During the 1990s and early 21st century, the Bureau of Land Management has conducted land exchanges in Nevada. These exchanges have typically involved a trade of environmentally sensitive land outside Clark County for Bureau land in the County. The land in Clark County moves to the private sector for

sale to land developers, particularly developers of large master-planned, densely occupied communities. The land swap policy has helped to accommodate population growth in the greater Las Vegas area.

4.1.6.2.5 Impacts to Public Services

Repository-generated impacts to public services from population changes in the region of influence would be small. Population changes in the region from the maximum repository-related employment case would be a small fraction of the anticipated population growth in the region. Even without the addition of repository jobs, the annual regional growth rate would increase by an estimated 2 to 4 percent, minimizing a possible need to alter plans already in place to meet projected growth.

As mentioned above, the majority of inmigrating workers would likely live in the many communities of Clark County, thereby dispersing the increased demand for public services, including schools. Southern Nye County, particularly Pahrump, also would experience an increased demand for public services. However, because the changes in population (about 1,100 residents in the peak year) would occur steadily over a long period, the County would be able to absorb increased demands in education, law enforcement, and fire protection. Repository-generated impacts to public services would be unlikely in Lincoln County.

4.1.6.3 Summary of Socioeconomic Impacts

The potential socioeconomic impacts associated with repository activities are summarized in this section. For all five socioeconomic parameters evaluated over construction, operations, and decontamination activities, the impacts would be very small, less than 1 percent of the baselines for the region of influence. The construction phase would experience greater impacts for employment, Gross Regional Product, and real disposable income. The operations and decontamination activities would cause the greater impact from increases in population and government spending.

The lower-temperature operating mode and the higher-temperature operating mode would have similar potential impacts. Composite employment, which includes workers directly associated with the construction activity and other indirect workers (food service providers and auto mechanics for example), would peak in 2006. The increase of 3,400 workers represents a 0.36 percent increase to the expected baseline. Gross Regional Product would also peak in 2006 as various goods and services associated with the construction activities were consumed. The expected increase in Gross Regional Product for 2006 is about $160 million, (all values for economic parameters are expressed in 2001 dollars) or 0.31 percent of the baseline. Peak years for the other socioeconomic impacts would be delayed until the operations period. Population increases caused by the increased employment opportunities would peak in 2030, at about 6,200 or less than 0.25 of a percent of the baseline for the year. Government spending would peak in 2030 at $22 million or 0.22 percent of the baseline. Disposable income would also be highest during the operations period, peaking in 2029 at $149 million, or 0.23 percent of the baseline. Impacts during the subsequent decontamination activities, monitoring period, and closure phase would be similar to or smaller than the impacts summarized above.

4.1.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY IMPACTS

This section describes potential health and safety impacts to workers (occupational impacts) and to members of the public from preconstruction testing and performance confirmation, construction, operation and monitoring, and closure activities. The analysis estimated health and safety impacts separately for involved workers and noninvolved workers for each repository phase. Involved workers are craft and operations personnel who would be directly involved in the activities related to facility construction and operations, including excavation activities; receipt, handling, packaging, aging, and emplacement of spent nuclear fuel and high-level radioactive waste materials; maintenance of the solar

power facility; monitoring of the condition and performance of the waste packages; and eventual closure of the repository. Noninvolved workers are managerial, technical, supervisory, and administrative personnel who would not be directly involved in the above activities. This section describes impacts from the receipt of uncanistered spent nuclear fuel. Impacts for canistered fuel would be smaller, as reported in Appendix F, Section F.2.

The types of potential health and safety impacts to repository workers include those from industrial hazards common to the workplace, those from exposure to naturally occurring and manmade radiation and radioactive materials present in the workplace, and those from exposure to naturally occurring nonradioactive airborne hazardous material. Members of the public could be exposed to airborne releases of naturally occurring and manmade radionuclides and naturally occurring hazardous materials. Estimates of human health impacts to members of the public are based on information presented in Section 4.1.2.

Appendix F describes the methodology, data, and data sources used for the calculations of health and safety impacts to workers and supporting detailed results. It also contains a human health impacts primer.

4.1.7.1 Impacts to Occupational and Public Health and Safety from Preconstruction Testing and Performance Confirmation

Preconstruction testing and performance confirmation activities would be similar to the activities performed during Yucca Mountain site characterization. Their purpose would be to ensure that systems, operations, and materials were functioning as predicted. These activities could include the construction of surface facilities to support performance confirmation, excavation of exploratory tunnels, and testing and monitoring activities in the drifts. Chapter 3 describes site characterization activities and the resulting affected environment.

Potential health and safety impacts that could occur during preconstruction testing and performance confirmation activities include those common to an industrial work setting, radiological impacts to the public and workers from exposure to radon-222 and its decay products, external radiation exposure of workers in the subsurface environment, and the potential for exposure to naturally occurring hazardous materials generated by excavation activities. Section 4.1.7.2 contains additional information on these potential exposure pathways. No spent nuclear fuel and high-level radioactive waste would be present during preconstruction testing and performance confirmation activities, so radiation exposure of workers from this source would not occur.

Impacts are likely to be very small during preconstruction testing and performance confirmation activities. Incremental health and safety impacts to workers for the performance confirmation period would be less than 2 percent of those estimated for the construction, operation and monitoring, and closure phases, based on comparisons of worker activities and the number of worker-years between site characterization (DIRS 104957-DOE 1994, all) and repository activities (see Appendix F). Potential radiological impacts to members of the public would be less than those estimated for the construction phase (Section 4.1.7.2). The probability of latent cancer fatality in the offsite maximally exposed individual would be about 0.0000002. No latent cancer fatalities (less than 0.004) would be likely in the potentially exposed population.

4.1.7.2 Impacts to Occupational and Public Health and Safety from Initial Construction

This section describes estimates of health and safety impacts to repository workers and members of the public for the 5-year initial construction phase. During this phase, DOE would build the surface facilities, excavate the main drifts, and excavate enough emplacement drifts to support initial emplacement activities. Potential health and safety impacts to workers would occur from industrial

hazards, exposure to naturally occurring radionuclides, and exposure to naturally occurring cristobalite and erionite in the rock at the Yucca Mountain site. Potential health impacts to members of the public would be from exposure to airborne releases of naturally occurring radionuclides and hazardous materials.

4.1.7.2.1 *Occupational Health and Safety Impacts*

Industrial Hazards. The analysis estimated health and safety impacts to workers from hazards common to the industrial setting in which they would be working using statistics for similar kinds of operations in the DOE complex and estimates of the total number of full-time equivalent worker years that would be involved in the activity. The statistics that the analysis used are from the DOE Computerized Accident/ Incident Reporting and Recordkeeping System (DIRS 147938-DOE 1999, all). These statistics reflect recent DOE experience for these types of activities. Appendix F, Section F.2.2.2, contains more information on the selection of impact statistics.

Estimates of impacts were based on the number of full-time worker years during the construction phase for the repository operating modes. Table 4-21 lists the estimated impacts to workers from industrial hazards for the repository construction phase. The table lists impacts for three types of industrial safety impacts; total recordable cases of injuries and illnesses that are work-related, total lost workday cases, and fatalities (see the discussion in Appendix F, Section F.2.2).

Table 4-21. Impacts to workers from industrial hazards during initial construction phase.[a,b]

Worker group and impact category	Operating mode	
	Higher-temperature	Lower-temperature
Involved workers		
Total recordable cases	340	340 - 370
Lost workday cases	160	160 - 180
Fatalities	0.16	0.16 - 0.18
Noninvolved workers		
Total recordable cases	55	55 - 61
Lost workday cases	27	27 - 30
Fatalities	0.048	0.048 - 0.054
All workers (totals)[c]		
Total recordable cases	400	400 - 430
Lost workday cases	190	190 - 210
Fatalities	0.21	0.21 - 0.23

a. Source: Appendix F, Table F-12. Numbers are rounded to two significant figures.
b. The analysis assumed that the construction phase would last 44 months for surface facility construction and 60 months for subsurface construction activities.
c. Totals might differ from sums of values due to rounding.

No worker fatalities would be expected during construction for any of the operating modes. For the higher-temperature operating mode, the estimated fatalities are 0.21. The range for the lower-temperature operating mode is 0.21 to 0.23 fatality.

Naturally Occurring Hazardous Materials. Two types of naturally occurring hazardous materials could be encountered by workers at the Yucca Mountain site—cristobalite, a form of crystalline silica (silicon dioxide, SiO_2), and erionite, a naturally occurring zeolite. Both are present in the subsurface rock at Yucca Mountain and have the potential to become airborne during repository excavation and activities involving excavated rock and would be released during tunneling operations. It could also be released with dust from the excavated rock pile. Erionite is a natural zeolite that occurs in the rock layers below the proposed repository level (see Chapter 3, Section 3.1.3). It might also occur in rock layers above the repository level but activities to date have not found it in those layers. Erionite could become a hazard during vertical boring operations if the operations passed through a rock layer containing erionite (which

would be unlikely), and during excavation for access to the lower block. Additional information on the potential hazards of these naturally-occurring materials is found in Appendix F, Section F.1.2.

Cristobalite is present in the welded tuff at the repository level and would become airborne in the repository environment during excavation and rock moving activities. The welded tuff has an average cristobalite content of between 18 and 28 percent (DIRS 104523-CRWMS M&O 1999, p. 4-81).

DOE would use engineering controls during subsurface work to control exposures of workers to silica dust. Water would be applied during excavation activities to wet both the rock face and the broken rock to minimize airborne dust levels. Wet or dry dust scrubbers would capture dust that the water sprays did not suppress. The fresh air intake and the exhaust air streams would be separated to prevent increased dust concentrations in the drift atmosphere from recirculation. In addition, the ventilation system would be designed and operated to control ambient air velocities to minimize dust resuspension. DOE would monitor the working environment to ensure that workers were not exposed to dust concentrations higher than the applicable limits for cristobalite. If engineering controls were unable to maintain dust concentrations below the limits, administrative controls such as access restrictions or respiratory protection would be used until the engineering controls could establish acceptable conditions. Similar controls would be applied, if required, for surface workers. DOE expects that exposure of workers to silica dust would be below the applicable limits and potential impacts to subsurface and surface workers would be very small.

DOE does not expect to encounter erionite layers either during vertical boring operations (which would be through rock layers above known erionite layers) or during excavation to provide access to the lower block and offset areas. Access excavation would be planned to avoid any identified layers of erionite (DIRS 104532-McKenzie 1998, all). If erionite was encountered during excavation for access to the lower block or during vertical boring operations, the engineering controls described above for cristobalite would be instituted and, if necessary, administrative controls would be used until acceptable conditions were reestablished.

Radiological Health Impacts. Spent nuclear fuel and high-level radioactive waste would not be present at the repository site during the construction phase and so would not contribute to radiological impacts. Potential radiological health impacts to involved and noninvolved workers in subsurface facilities during the initial construction phase would be from two sources: inhalation of naturally occurring radon-222 and its decay products following emanation of the radon from the surrounding rock, and external radiation dose from naturally occurring radionuclides in the drift walls, principally potassium-40 and radionuclides in the uranium decay series (DIRS 104544-CRWMS M&O 1999, Sections 4 and 5). Radon-222 is a noble gas of the uranium-238 decay series. Because it is a noble gas, radon emanates from the rock into the drifts, where elevated concentrations of radon-222 and its decay products could occur in the repository atmosphere (see Chapter 3, Section 3.1.8.2). Workers in surface facilities and members of the public would also be exposed to naturally occurring radon-222 and decay products as these radionuclides would be released from the subsurface in exhaust ventilation air. Section 4.1.2.2.2 provides more detailed discussion of these airborne release exposures.

Measurements in the Exploratory Studies Facility indicated an underground ambient external dose rate from radionuclides in the drift walls of about 50 millirem per work year of 2,000 hours underground. This is slightly higher than the dose rate from the cosmic and cosmogenic components of natural background radiation on the surface of about 40 millirem per year in the Amargosa Valley region (see Section 3.1.8.2). This analysis considers the underground ambient external radiation dose to be part of the involved worker occupational dose.

Table 4-22 lists estimated potential doses and radiological health impacts for the construction phase to involved workers, noninvolved workers, and the total for all workers. It includes estimated doses and

Table 4-22. Radiation dose and radiological health impacts to workers during the initial construction phase.[a,b,c]

Worker group and impact category	Operating mode	
	Higher-temperature	Lower-temperature
Maximally exposed worker		
Dose, rem		
Involved	1.3	1.3
Noninvolved	0.33	0.33
Probability of latent cancer fatality		
Involved	0.00052	0.00052
Noninvolved	0.00013	0.00013
Worker population		
Collective dose (person-rem)		
Involved	680	680
Noninvolved	37	37
Total[d]	720	720
Number of latent cancer fatalities		
Involved	0.27	0.27
Noninvolved	0.015	0.015
Total[d]	**0.29**	**0.29**

a. Numbers are rounded to two significant figures.
b. Source: Appendix F, Table F-11.
c. Only subsurface workers have potential for measurable radiation dose (from natural sources) during the initial construction phase.
d. Totals might differ from sums of values due to rounding.

radiological health impacts for the maximally exposed involved worker and for the involved worker population; radiological health impacts for the maximally exposed noninvolved worker and for the noninvolved worker population; and the estimated collective dose and radiological health impacts for the combined population of workers. Estimated doses were converted to estimates of latent cancer fatalities using a dose-to-risk conversion factor of 0.0004 latent cancer fatality per rem (see Appendix F, Section F.1.1.5). Radiological health impacts for maximally exposed individuals are presented as the increase in the probability of a latent cancer fatality resulting from the radiation dose received. Radiological health impacts for exposed populations are presented as the number of latent cancer fatalities estimated to result from the collective radiation dose received.

During the initial construction phase the only source of radiation would be from naturally occurring radionuclides in the subsurface, so radiological health impacts to the surface facility workforce would be much lower than those to the subsurface facility workforce. Values presented in Table 4-22 are those for subsurface workers (see Appendix F, Table F-11).

The estimated increase in the number of latent cancer fatalities for workers would be low (about 0.3); the estimated increase in the likelihood that an individual worker would die from a latent cancer fatality would also be small (about 0.0005).

4.1.7.2.2 *Public Health Impacts*

Naturally Occurring Hazardous Materials. Section 4.1.2.2.1 presents estimated annual average concentrations of cristobalite at the *site boundary* where members of the public could be exposed during the construction phase. The analysis estimated concentrations of about 0.02 microgram per cubic meter for the operating modes, and health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower at locations of public exposure. Impacts would be very small.

Radiological Health Impacts. Potential radiological health impacts to the public during the construction phase would come from exposure to airborne releases of naturally occurring radon-222 and its decay products in the subsurface exhaust ventilation air. Estimates of radiation doses for the offsite maximally exposed individual and the potentially exposed population are presented in Section 4.1.2.2.2. The offsite maximally exposed individual is a hypothetical member of the public at a point on the land withdrawal boundary that would receive the highest radiation dose and resultant radiological health impact. This location would be at the southern boundary of the land withdrawal area. The exposed population is that within 80 kilometers (50 miles) of the repository (see Section 3.1.8). Estimated doses to members of the public were converted to estimates of latent cancer fatalities using a dose-to-risk conversion factor of 0.0005 latent cancer fatality per rem for members of the public (see Appendix F, Section F.1.1.5).

Table 4-23 lists the estimated doses and radiological health impacts to members of the public from the 5-year initial construction phase. The radiological health impacts to the public from repository construction would be very small (with 0.02 latent cancer fatality or less estimated for all of the operating modes). The estimated individual risk of contracting a latent cancer fatality for the maximally exposed individual would be 0.000001 or less over the 5-year phase.

Table 4-23. Radiation doses and radiological health impacts to the public during the initial construction phase.[a,b,c]

	Operating mode			
	Entire phase		Maximum annual	
Dose and health impact	Higher-temperature	Lower-temperature	Higher - temperature	Lower-temperature
Maximally exposed individual[d]				
Dose (millirem)	1.7	1.7 - 2.0	0.43	0.43 - 0.53
Latent cancer fatality probability	8.5×10^{-7}	$0.85 - 1.0 \times 10^{-6}$	2.1×10^{-7}	$2.1 - 2.6 \times 10^{-7}$
Exposed 80-km population[e]				
Collective dose (person-rem)	33	33 - 40	8.4	8.4 - 10
Number of latent cancer fatality	0.017	0.017 - 0.020	0.0042	0.0042 - 0.0052

a. Numbers are rounded to two significant figures.
b. Source: Table 4-2.
c. All of the dose and impact are from naturally occurring radon-222 and decay products.
d. Located at the southern boundary of the land withdrawal area.
e. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).

4.1.7.3 Occupational and Public Health and Safety Impacts from Operation and Monitoring

This section describes possible health and safety impacts to workers and members of the public for the operation and monitoring phase. This phase has two main components: the operations period (including continuing subsurface development) and the monitoring period. The overall phase length would range from 100 years for the higher-temperature operating mode up to 324 years for the lower-temperature operating mode. Impacts of the operations period and the monitoring period are described below.

4.1.7.3.1 *Operations Period – Handling, Emplacement, and Continuing Development*

This period would consist of a 24-year period for operations, including the receipt, handling, packaging, possible aging, and emplacement of spent nuclear fuel and high-level radioactive waste. There would be a concurrent (except for the last two years) 22-year period for continued construction (development) of underground repository features, including access drifts, emplacement drifts, shafts, and so on. Where aging of commercial spent nuclear fuel could occur under the lower temperature operating mode an

additional 26 years of emplacement and handling would be needed, for a total operations period length of 50 years.

4.1.7.3.1.1 Occupational Impacts

Industrial Hazards. Table 4-24 summarizes health and safety impacts from common industrial hazards for the operations period. Impacts were estimated separately for surface operations, subsurface emplacement operations, and subsurface drift development operations, then were summed to develop these results.

Table 4-24. Impacts to workers from industrial hazards during the operations period.[a]

Worker group and impact category	Operating mode	
	Higher-temperature	Lower-temperature
Involved workers		
Total recordable cases	1,200	1,200 - 1,700
Lost work day cases	590	620 - 840
Fatalities	0.90	0.91 - 1.4
Noninvolved workers		
Total recordable cases	300	310 - 470
Lost workday cases	150	150 - 230
Fatalities	0.31	0.31 - 0.45
All workers (totals)[b]		
Total recordable cases	1,500	1,500 - 2,200
Lost workday cases	740	770 - 1,100
Fatalities	1.2	1.2 - 1.9

a. Values taken from Appendix F, Table F-22.
b. Totals might differ from sums of values due to rounding.

About 1.2 fatalities were estimated for the higher-temperature operating mode, with a range of 1.2 to 1.9 fatalities estimated for the lower-temperature operating mode. The highest estimates would be where aging would be used (longer operations period, more worker-years) with maximum spacing of the waste packages, which results in the largest repository and thus more excavation.

Naturally Occurring Hazardous Material. As discussed in Section 4.1.7.2.1 for the construction phase, DOE would use engineering controls and, if necessary, administrative worker protection measures to control and minimize impacts to workers from releases of cristobalite and erionite during the operations period. Controls would be necessary mainly for continuing development activities underground but also for activities associated with the excavated rock pile. As for the construction phase, impacts would be expected to be very small.

Radiological Health Impacts. Occupational radiological health impacts during the operations period would be a combination of impacts to surface workers during handling operations, and impacts to subsurface workers during development and emplacement operations. These impacts are presented in Table 4-25.

The estimated radiological health impacts to the worker population for the 24 or 50-year operations period would range from 3.1 to 4.8 latent cancer fatalities. Estimated radiological health impacts to the maximally exposed individual would range from 15 to 30 rem, with a corresponding probability of latent cancer fatality ranging from 0.0060 to 0.012. The principal contributors to radiological health impacts would be surface facility operations, which would involve the receipt, handling, and packaging of spent nuclear fuel and high-level radioactive waste for emplacement and subsurface monitoring activities.

Table 4-25. Radiation dose and radiological health impacts to workers during the operations period.[a,b]

Worker group and impact category	Operating mode	
	Higher-temperature	Lower-temperature
Maximally exposed worker		
Dose, rem		
Involved	15	15 - 30
Noninvolved	1.5	1.5 - 1.8
Probability of latent cancer fatality		
Involved	0.0060	0.0060 - 0.012
Noninvolved	0.00060	0.00060 - 0.00072
Worker population		
Collective dose (person-rem)		
Involved	7,500	7,600 - 12,000
Noninvolved	150	160 - 170
Total[c]	**7,700**	**7,800 - 12,000**
Number of latent cancer fatalities		
Involved	3.0	3.0 - 4.8
Noninvolved	0.060	0.064 - 0.068
Total[c]	**3.1**	**3.1 - 4.8**

a. Numbers are rounded to two significant figures.
b. Source: Appendix F, Table F-23.
c. Totals might differ from sums of values due to rounding.

DOE would consider the inspection, testing, or retrieval of a waste package that had already been emplaced to be an off-normal condition of routine operations that it has already considered (see Chapter 2, Section 2.1.2.2.3). Any such operation would be carried out under the repository radiation protection program, and worker dose limits would apply. Therefore, any radiation dose from such an operation would already be included in the estimated doses to the maximally exposed workers and worker populations listed in Table 4-25.

4.1.7.3.1.2 Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.3.1 presents estimated annual average concentrations of cristobalite at the land withdrawal boundary where members of the public could be exposed during the operation and monitoring phase. The analysis estimated annual average concentrations of about 0.009 to 0.017 microgram per cubic meter for the operating modes. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower than for cristobalite at locations of public exposure. Impacts would be very small.

Radiological Health Impacts. Potential radiological health impacts to the public from operations period activities could result from exposure to naturally occurring radon-222 and its decay products released in subsurface exhaust ventilation air, and from exposure to radioactive noble gas fission products, principally krypton-85, that could be released from the Waste Handling Building during spent nuclear fuel handling operations. Krypton-85 and other noble gas fission products would be very small contributors to dose and potential radiological impacts, less than 0.01 percent of the dose from radon-222 and its decay products (see Section 4.1.2.3.2).

Section 4.1.2.3.2 presents estimates of dose to the public for the handling, emplacement, and continuing development (operations) period. Table 4-26 presents these doses and the potential radiological health impacts to the public for that period. Potential radiological health impacts would be very small. The probability of a latent cancer fatality occurring in the maximally exposed individual would be 0.000022 or less. The number of latent cancer fatalities estimated to occur in the exposed population would range from 0.12 to 0.42.

Table 4-26. Radiation doses and radiological health impacts to the public during the operations period.[a,b,c,d]

	Operating mode			
	Higher-temperature	Lower-temperature	Higher-temperature	Lower-temperature
Dose and health impact	Entire period		Maximum annual	
Maximally exposed individual[e]				
Dose (millirem)	12	17 - 43	0.73	1.0 - 1.3
Latent cancer fatality probability	6.0×10^{-6}	$0.83 - 2.2 \times 10^{-5}$	3.7×10^{-7}	$5.2 - 6.7 \times 10^{-7}$
Exposed 80-km population[f]				
Collective dose (person-rem)	230	320 - 830	14	20 - 26
Number of latent cancer fatality	0.12	0.16 - 0.42	0.0071	0.010 - 0.013

a. Numbers are rounded to two significant figures.
b. Source: Table 4-4.
c. Greater than 99.9 percent of the dose would be from naturally occurring radon-222 and decay products.
d. Fuel handling activities during the operation and monitoring phase would last 24 years. Emplacement activities would last 24 years with no aging, and 50 years with aging. Continued subsurface development activities would last 22 years.
e. Individual located at the southern boundary of the land withdrawal area for all of the operations period (24 or 50 years).
f. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Section 3.1.8).

4.1.7.3.2 *Monitoring Period*

This period would last 76 years under the higher-temperature operating mode and up to 300 years under lower-temperature operating modes. The first 3 years of this period would include decontamination of surface fuel handling facilities in preparation for the long periods of monitoring and maintenance to follow, and ultimately for closure. Only monitoring and maintenance activities would take place during the remainder of the period, including periodic replacement of the solar facility components. Most of the potential operating modes would include active ventilation during this period, but 250 years of natural ventilation could be used, during which there would be lower ventilation flow rates (see Section 2.1.1.2.2).

4.1.7.3.2.1 Occupational Impacts

Industrial Hazards. Table 4-27 lists health and safety impacts from common industrial hazards for the monitoring period, including decontamination activities. Impacts were estimated separately for the surface facility decontamination operations, surface operations to support subsurface monitoring, and subsurface monitoring itself.

About 0.4 fatality would be expected to occur for the higher-temperature operating mode. The range of fatalities predicted for the lower-temperature operating mode is 0.44 to 1.1 fatalities with the largest value for long-term ventilation with aging of the spent nuclear fuel.

Naturally Occurring Hazardous Material. During monitoring and maintenance activities there would be little opportunity for large quantities of dust to be generated for extended periods of time. If necessary, and as discussed in Section 4.1.7.2.1 for the construction phase, DOE would use engineering controls and, if necessary, administrative worker protection measures such as respiratory protection to control and minimize impacts to workers from releases of cristobalite and erionite during monitoring activities.

Radiological Health Impacts. Occupational radiological health impacts during the monitoring period would be a combination of impacts to surface workers during facility decontamination and subsurface workers during monitoring and maintenance activities. These impacts are presented in Table 4-28.

Table 4-27. Impacts to workers from industrial hazards during the monitoring period.[a,b]

Worker group and impact category	Operating mode	
	Higher-temperature	Lower-temperature
Involved workers		
Total recordable cases	320	400 - 1,000
Lost work day cases	130	160 - 410
Fatalities	0.31	0.38 - 1.0
Noninvolved workers		
Total recordable cases	55	65 - 150
Lost workday cases	27	32 - 73
Fatalities	0.049	0.057 - 0.13
All workers (totals)[c]		
Total recordable cases	380	470 - 1,200
Lost workday cases	160	190 - 480
Fatalities	0.36	0.44 - 1.1

a. Values are rounded to two significant figures.
b. Source: Appendix F, Table F-31.
c. Totals might differ from sums of values due to rounding.

Table 4-28. Radiation dose and radiological health impacts to workers during the monitoring period.[a,b]

Worker group and impact category	Operating mode	
	Higher-temperature	Lower-temperature
Maximally exposed worker[c]		
Dose, rem		
Involved	18	18
Noninvolved	1.8	1.8
Probability of latent cancer fatality		
Involved	0.0072	0.0072
Noninvolved	0.00072	0.00072
Worker population		
Collective dose (person-rem)		
Involved	1,100	1,500 - 4,300
Noninvolved	36	46 - 140
Total[d]	**1,100**	**1,500 - 4,400**
Number of latent cancer fatalities		
Involved	0.44	0.60 - 1.7
Noninvolved	0.014	0.018 - 0.056
Total[d]	**0.44**	**0.60 - 1.8**

a. Numbers are rounded to two significant figures.
b. Source: Appendix F, Table F-32.
c. Maximally exposed worker is a subsurface involved worker who works in the subsurface environment for 50 years.
d. Totals might differ from sums of values due to rounding.

The estimated radiological health impacts to the worker population for the 76- to 300-year monitoring period would range from 0.44 to 1.8 latent cancer fatalities. The relatively wide range in impacts is due mainly to the differences in the length of the monitoring periods. Estimated radiological health impacts to the maximally exposed individual would be 18 rem for the range of operating modes, with a corresponding probability of latent cancer fatality of 0.0072. Estimated doses and radiological health impacts to the maximally exposed worker are based on a 50-year working lifetime. The principal contributor to radiological health impacts would be from subsurface facility monitoring and maintenance activities.

4.1.7.3.2.2 Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.3.1 presents estimated annual average concentrations of cristobalite at the land withdrawal boundary where members of the public could be exposed during the operation and monitoring phase. The analysis estimated annual average concentrations of 0.009 to 0.017 microgram per cubic meter; however, these concentrations are likely more representative of operations period activities while those during the monitoring period would be even lower. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower than for cristobalite at locations of public exposure. Impacts would be very small.

Radiological Health Impacts. Potential radiological health impacts to the public from monitoring period activities would result from exposure to naturally occurring radon-222 and its decay products released in subsurface exhaust ventilation air. No releases of radioactive material or radiation dose to the public are anticipated for decontamination activities (DIRS 152010-CRWMS M&O 2000, pp. 55-56).

Section 4.1.2.3.2 presents estimates of dose to the public for the monitoring period. Table 4-29 lists these doses and potential radiological health impacts to the public for that period. Potential radiological health impacts would be low. The probability of a latent cancer fatality occurring in the maximally exposed individual would be 0.000031 or less. The number of latent cancer fatalities estimated to occur in the exposed population would range from 0.75 to 1.7. Because of the length of the monitoring period compared to other project periods, most of the estimated radiological impacts to the public would occur during this period.

Table 4-29. Radiation doses and radiological health impacts to the public during the monitoring period.[a,b,c,d]

	Operating mode			
	Higher-temperature	Lower-temperature	Higher-temperature	Lower-temperature
Dose and health impact	Entire period		Maximum annual	
Maximally exposed individual[e]				
Dose (millirem)	29	30 - 62	0.41	0.59 - 0.89
Latent cancer fatality probability	1.5×10^{-5}	$1.5 - 3.1 \times 10^{-5}$	2.1×10^{-7}	$3 - 4.4 \times 10^{-7}$
Exposed 80-kilometer population[f]				
Collective dose (person-rem)	600	1,500 - 3,500	8	11 - 17
Number of latent cancer fatalities	0.31	0.75 - 1.7	0.004	0.0057 - 0.0085

a. Numbers are rounded to two significant figures.
b. Source: Table 4-5.
c. All dose would be from naturally occurring radon-222 and decay products.
d. Monitoring and maintenance period would last from 76 to 300 years.
e. Individual located at the southern boundary of the land withdrawal area for 10 years.
f. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).

4.1.7.4 Impacts to Occupational and Public Health and Safety from Closure

This section contains estimates of health and safety impacts to workers and to members of the public for the closure phase. The length of this phase depends on the operating mode. The higher-temperature operating mode closure phase would last 10 years, while closure for the lower-temperature operating mode would range from 11 to 17 years in length.